GPS/GLONASS Geodesy

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Introduction:

The AUSLIG Space Geodesy Analysis Centre undertakes Global Positioning System (GPS), Satellite Laser Ranging (SLR), Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) and GLONASS data processing and analysis, and the combination of these techniques. In addition, development of the combination solutions have further progressed to include Very Long Baseline Interferomety (VLBI) results, the Solution Independent Exchange Format (SINEX files), which are produced by VLBI Analysis Centres.

Global, Regional and National GPS Geodesy.

GPS data processing activity focuses on our obligations as an International GPS Service (IGS) Regional Network Associated Analysis Centre (RNAAC), the Regional Geodetic Networks Working Group of the Permanent Committee for GIS Infrastructure for Asia and the Pacific (PCGIAP), AUSLIG initiated projects of national interest, such as the provision of the geodetic component at the network of high precision tide gauges of the Australian Baseline Sea Level Monitoring Array (ABSLMA) for absolute sea level determination, and as a service to other Commonwealth agencies such as the Department of Defence, Airservices Australia and the Antarctic Division.

The RNAAC computes daily station coordinates for the ARGN stations (including Antarctic sites) using IGS products for GPS satellite ephemerides and Earth Orientation Parameters (EOP). These are submitted as weekly solutions to the IGS for combination by the IGS Global Network Associated Analysis Centres (GNAACs). Figure 1 shows the Australian Regional GPS Network (ARGN) sites that are computed in an AUSLIG weekly regional solution that is submitted to the IGS. Figure 2 is a plot of a typical time series of the weekly solutions for the ARGN computed by AUSLIG.

Figure 1: Locations of ARGN sites in the AUSLIG Regional Solution.

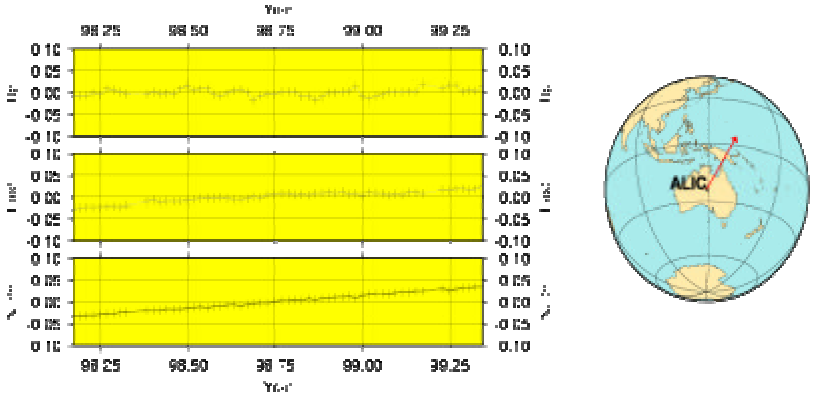

Figure 2: GPS Time Series for Alice Springs ARGN site.

All other GPS computations undertaken at AUSLIG also comprises the determination of its own orbit and EOP products together with station position estimates. The computation standards, processing techniques, results and comparisons are documented in Govind et al. (1996), AUSLIG (1998), Govind et al. (1998) and Dawson et al. (1998). The satellite trajectories and estimated EOPs compare with the IGS combined orbit product having a RMS at the 5-6 cm level. Figure 3 shows the global distribution of the selected IGS sites that are used in a typical AUSLIG GPS orbit determination computation. Figure 4 shows the differences between an AUSLIG determined orbit and the IGS final combined product. Figure 5 show the differences in the radial direction between AUSLIG estimated pole position and the IGS distributed values for one-week solutions for July, August, September and October 1998.

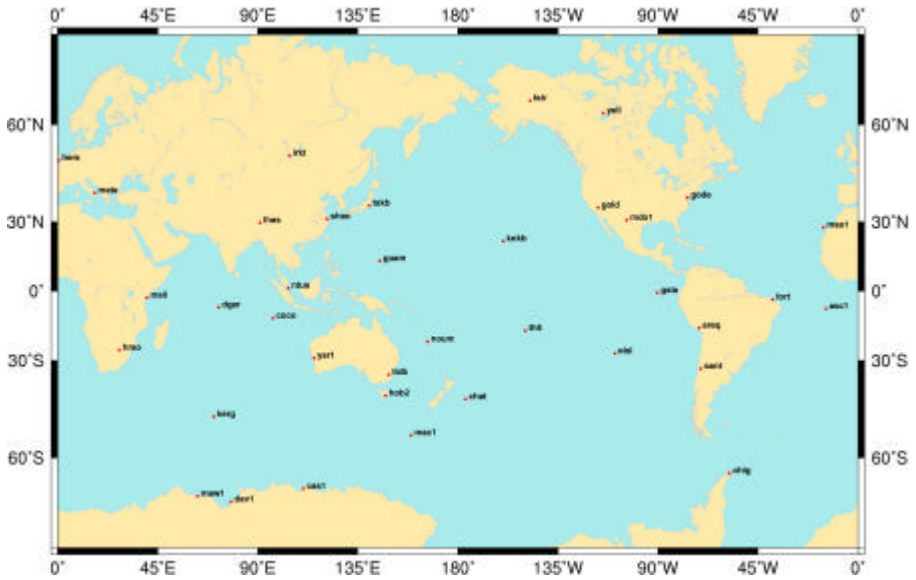

Figure 3 Distribution of a Typical Global IGS GPS station set used in a AUSLIG Determination Orbit Solution

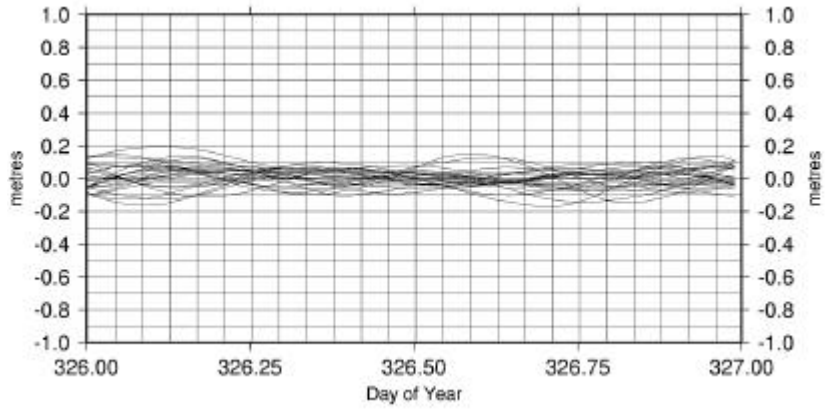

Figure 4 Radial Orbit Difference; IGS final product versus AUSLIG (22 November 1998). RMS difference 0.058m

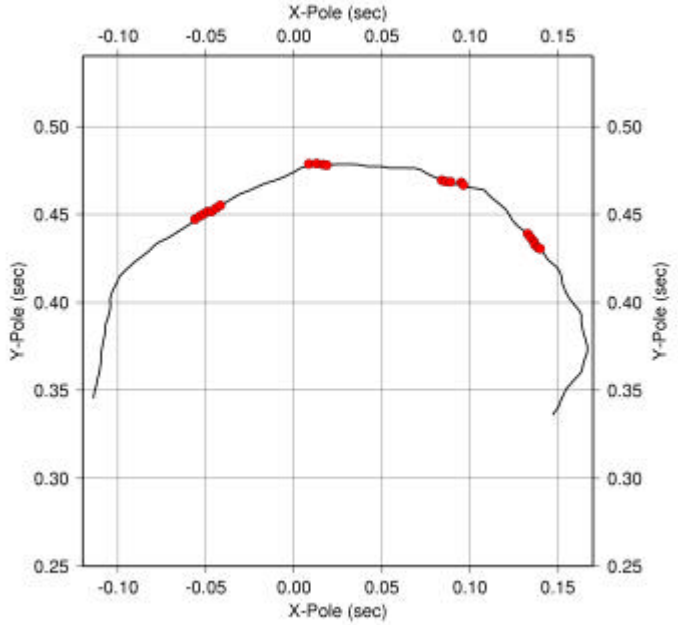

Figure 5 IGS X/Y Pole (solid line) versus AUSLIG X/Y Pole (circle), July, August, September, October 1998.

A fundamental regional geodetic objective is the densification of the ITRF and its relationship with local and national geodetic datums (AUSLIG, 1998) and this is being achieved through Working Group 1 of PCGIAP. Two cooperative, intensive and multi-technique observation and computation campaigns have been undertaken; Asia Pacific Regional Geodetic Project (APRGP) 1997 and 1998. Figure 6 shows the distribution of the GPS stations of the APRGP97 campaign. Figure 7 shows the distribution of GPS sites in the APRGP98 campaign. The APRGP97 was observed during October 1997 and the APRGP98 was observed during November 1998.

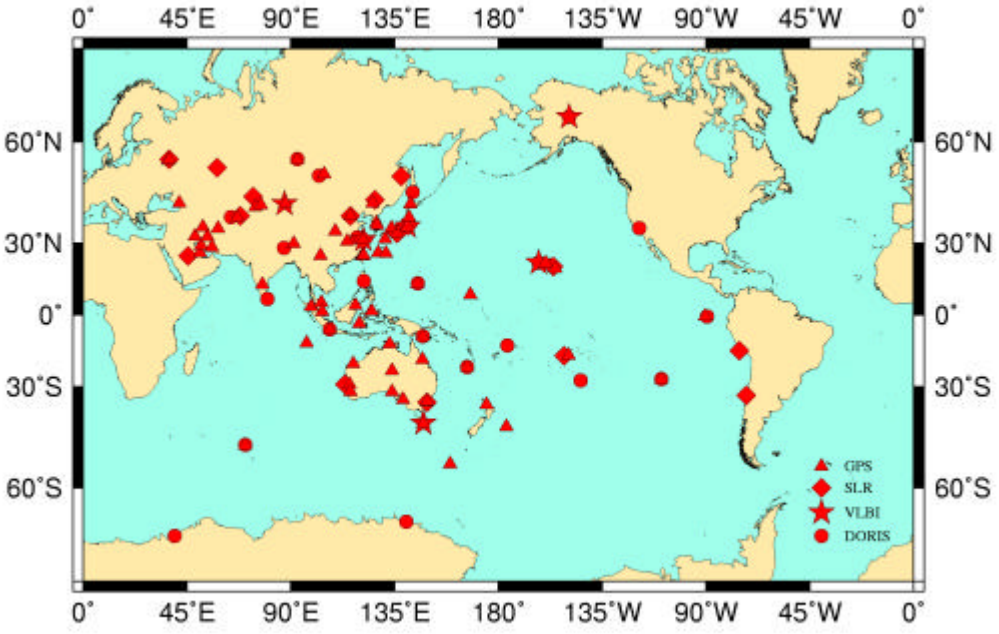

Figure 6 APRGP97 GPS Observing Stations

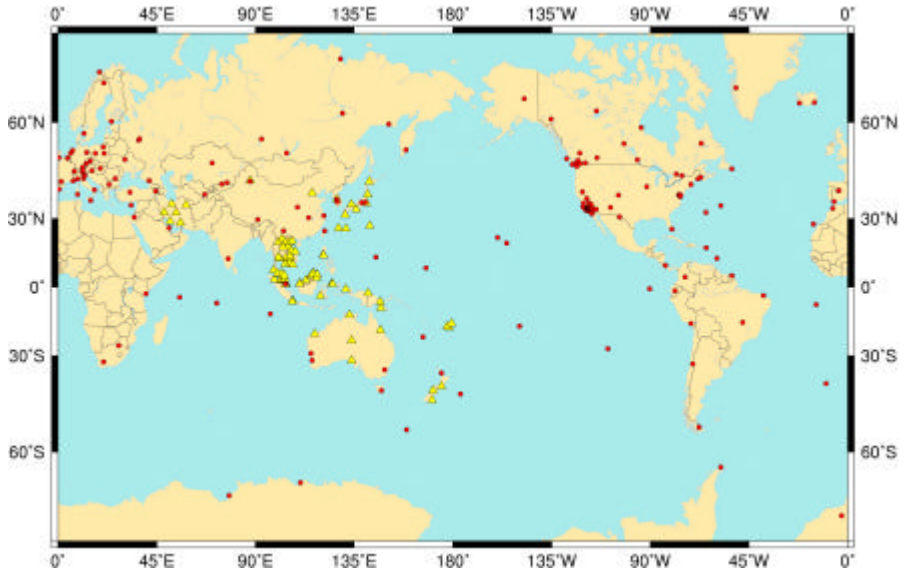

Figure 7 APGP98 GPS stations (triangles) and IGS stations (circles).

APRGP97 includes GPS observations from 73 GPS receivers throughout the Asia Pacific region, this data set together with a further 17 global GPS receivers was observed from October 12th to October 20th 1997, GPS week 927 (0-6) and 928 (0-1). The data set includes observations from both the International GPS Service (IGS) and non-IGS/national agency GPS receivers.

Results of the APRGP97 campaign are given in AUSLIG (1998), Dawson et al. (1998) and Govind et al. (1998). The RMS of the differences between the AUSLIG determined Set of Station Coordinates (SSC) compared to ITRF96 was 5, 4 and 9 mm in the East, North and Up components respectively. A comparison with the MIT GNAAC has a RMS of differences of 7, 4 and 16 mm in the East, North and Up components respectively.

The results of the subsequent (and significantly larger) APRGP98 campaign observed during November 1998 are being prepared for presentation at the meeting of Working Group 1 to be held 12th – 13th July 1999, Ho Chi Minh City, Vietnam and in Govind at al. (1999b). Figure 7 shows the distribution of the APRGP98 set of GPS stations.

As part of our commitment to the further densification of the ITRF in the Asia Pacific region, a high precision GPS geodetic network comprising eight stations (observed in August 1997, November 1997 and May 1998) was computed for the General Department of Land Administration, Socialist Republic of Vietnam.

Geodetic Fixing of Tide Gauge Benchmarks using GPS

Fourteen bench mark tide gauges designated the Australian Baseline Sea Level Monitoring Array (ABSLMA), shown in figure 8, are deployed along the coast of the Australian continent. In order to monitor changes in absolute sea level, the vertical motion of the crust at the tide gauge location must also be monitored in an accurate, global terrestrial reference frame. The computation and analysis of GPS observations at the ABSLMA tide gauge sites for absolute sea level monitoring is undertaken on an opportunity basis, that is, when a coordinated, long occupation observation campaign is undertaken. A one week occupation at ABSLMA tide gauge benchmarks was undertaken during May 1995. The observation campaign, computation standards and procedure and the results and analysis are given in Govind et al. (1996).

Figure 8 Australian Baseline Sea Level Monitoring Array of Tide Gauges.

DORIS

The SPOT2, TOPEX/POSEIDON SPOT3 and SPOT4 spacecraft are equipped with DORIS receivers as their prime navigation system. DORIS data from the SPOT-2 satellite has been routinely processed giving typical results for station coordinates with an RMS of the differences at the 3, 5 and 2 mm level in the East, North and Up components respectively. The SPOT 4 receiver includes the new DIODE navigator, which calculates the spacecraft's real-time on-board orbit. The now fully operational DIODE navigator produces results having an accuracy of 2.7, 4.0 and 3.0 metre RMS for the radial, along track and cross track components respectively. An improved version of DIODE is planned for the ENVISAT, JASON and SPOT5 spacecraft with expected accuracies of better than 1 meter 3D RMS. It is thus possible to offer efficient navigation possibilities to spacecraft currently being designed, especially for constellations of Low Earth Orbiting satellites.

GLONASS

The International GLONASS Experiment is described in Willis et al. (1998). SLR data to all the GLONASS satellites observed during the period of this experiment was processed. The SLR determined orbits are compared with the trajectories of the microwave-determined orbits of some of the IGS Analysis centres. These results are given in Govind et al. (1999c, 1999d). The processing of the GLONASS microwave data has only just begun.

Future Work

The current thrust is to apply the AUSLIG GPS processing and analysis system to undertake precise orbit determine for Low Earth Orbiting Satellites (LEOS) that carry a geodetic GPS receiver for atmospheric studies, altimetry and global gravity field improvement.

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